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544 U.S. PTO

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DIRECT DIAL SYSTEM: 312-845-3919
TELEX NO.: 206281
TELECOPIER: 312-701-2361

Attorney Docket No. 1704345

Date: December 26, 1997

BOX: PATENT APPLICATION
ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

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Sir:

We enclose the following papers for filing in the United States Patent and Trademark Office in association with a new patent application

By: **Albert BAUER**

For: **AIR CONDITIONING APPARATUS**

☒ Application - 21 sheets; including 31 claims total, 1 independent claim.

☒ 8 sheet(s) of drawings.

☐ Declaration and Power of Attorney.

☐ An Assignment of the invention to _____

☒ Benefit of the filing dates of German application No. 196 54 542.0, filed December 27, 1996 and German application No. 196 54 955.8, filed October 15, 1997 is claimed pursuant to 35 U.S.C. 119.

☐ Certified copies of German application No. 196 54 542.0 and German application No. 196 54 955.8

☐ A Verified Statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27.

☐ An Information Disclosure Statement Under 37 CFR 1.97, including ____ references.

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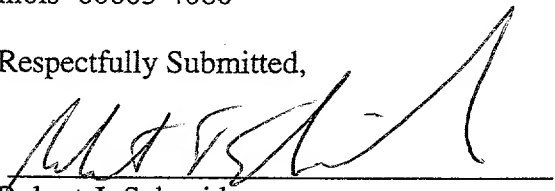
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AIR-CONDITIONING APPARATUS

FIELD OF INVENTION

The invention relates to an air-conditioning apparatus which regulates the temperature in at least one room by ventilation with heated or cooled air to a predetermined temperature desired value.

BACKGROUND OF THE INVENTION

Air-conditioning apparatuses are used to create in the air-conditioned rooms comfortable conditions of occupation at any time of year, as they hold the temperature and humidity of the room air within fixed limits and provide for a sufficient ventilation with fresh air.

In winter the supply air temperature is higher than the room air temperature when the air is also meant to warm the room, and in summer the supply air is injected at a lower temperature in order to hold the room at the desired cooled room air temperature.

Ordinarily, to achieve this a conventional air-conditioning apparatus circulates too high an amount of air, the temperature of which has been adapted to the heating and cooling requirement. There, it is regarded as disadvantageous that a large volume of air is circulated even after the desired temperature has already been reached. Moreover, the danger exists that the supply air will be blown into the room over the supply air channel and will immediately leave the room to be air-conditioned over the exhaust air channel. There takes place a very small mixing of the new supply air with the air present in the room.

Further, in the air-conditioning of several rooms there is the problem that different desired temperatures are present in the rooms. An adaptation of the temperatures which takes into consideration the comfort in each room is possible only with difficulty.

SUMMARY OF THE INVENTION

Underlying the present invention is the problem of giving an air-conditioning apparatus which operates economically, ensures more comfortable room conditions and an optimal mixing of the room air with the supply air, in order to achieve a rapid adaptation to the heating, cooling, humidifying and dehumidifying desired values.

This problem is solved according to the invention by the means that the air-conditioning apparatus which regulates the temperature in at least one room to a predetermined temperature desired value by ventilation with heated or cooled air. The apparatus is provided with a supply air motor which feeds the supply air over a supply air channel to the room to be air-conditioned, with a cooling and/or heating device introduced into the supply air channel for the cooling or warming of the supply air, and with an exhaust

air motor which draws the exhaust air over an exhaust channel out of the room to be air-conditioned, in which the desired value for the regulator of the exhaust air motor builds up a room excess pressure established with respect to the outside pressure. Further advantageous embodiments of the invention form the objects of the subclaims.

Underlying the invention is the perception that the greater the excess pressure is in a room to be air-conditioned, the better is the ventilation by the supply air blown through the room. Therewith the room warms up faster, the efficiency of the installation is improved and great temperature fluctuations in the room are avoidable for example, very warm at the top and very cool at the bottom, as are also temperature differences over the length and width of the room.

A good flow of air through the room ensures that in the shortest possible time and with a smaller amount of air, a room is heated, cooled, humidified or dehumidified. The smaller amount of supply air blown in is found pleasant. For the faster adaptation of the heating, cooling, humidifying and dehumidifying desired values, the efficiency of the air-conditioning apparatus is improved.

In particular, the desired value for the regulator of the exhaust air motor is determined in dependence on the outside temperature and/or on the supply air temperature and/or on the supply air pressure. This regulating of the exhaust air motor, in dependence on the outside temperature and/or on the supply air temperature and/or on the supply air pressure, is important for the optimization of the air flow. The higher the supply air temperature or the supply air pressure is, the greater the excess pressure would have to be for a favorable flow of air through the room to be air-conditioned with the supply air. The lower, however, the outside temperature is, the higher as a rule, therefore, the excess pressure in the room to be air-conditioned has to be. There must, therefore, be present a greater excess pressure for the ensuring of an optimal flow of air through the room with the blown-in supply air.

On the one hand, preferably the actual value for the regulator of the exhaust air motor is determined by pressure difference between the channels, which is calculated from the difference between the absolute value of the pressure in the supply air channel and the absolute value of the pressure in the exhaust air channel. It will then be the case that, for example, excess pressure disturbances will occur in the air-conditioning apparatus in several rooms as a result of opening of windows in individual rooms, and therewith this results in undesired rise of the excess pressure in the other rooms, taking place through the regulation of the exhaust air motor, by reason of the pressure loss in one room.

On the other hand, preferably the actual value for the regulator of the exhaust air motor is formed by the room pressure difference which is calculated from the difference between the outside pressure and the room pressure.

Here above all the room excess pressure varies exclusively over a predetermined temperature range of the outside temperature and/or of the supply air temperature, with change of the outside temperature or of the supply air temperature, in which with an outside

temperature before this temperature range the room excess pressure has in each case a certain constant value and with an outside temperature or supply air temperature after this temperature range the room excess pressure always has a further definite constant value. Above all, with rising outside temperature, in that temperature range the room pressure falls from a maximum excess pressure to a minimal excess pressure.

Thereby account is taken of two opposite demands. On the one hand, for a good flow of air through the room to be air- conditioned it is required that the excess pressure be as high as possible. On the other hand, the excess pressure must not be too great, because it is otherwise felt to be disagreeable, and with too great excess pressure doors open themselves or no longer open can be opened or closed only with high expenditure of force.

So that a comfortable regulation will be accomplished and an excess pressure will be ensured independently from the height or the floor level of the room to be air-conditioned, the room difference pressure is measured at a height or level over 0 (room height). Room height corresponds to outside elevation in respect to sea level.

According to one embodiment of the invention the temperature of the supply air and the channel pressure of the supply air are coupled with one another in such manner that both in dependence on the height of the room temperature to the height of the supply air temperature and also in dependence on the height of the room temperature to the height of the desired value of the room temperature, the channel pressure of the supply air is raised or lowered in the room, rooms or room zones.

The advantages herewith achieved lie especially in that a great volume of air-conditioned air is not unnecessarily circulated, but always only that volume that is required for a maximally rapid adaptation of the actual room values to the predetermined desired values.

In this manner not only are savings in energy achieved, but people in the room find it considerably more agreeable when a relatively strong air movement takes place only when the temperature of the blown-in air deviates from the actual temperature. With conventional air-conditioning apparatuses, in contrast, especially during the morning warming-up phase, even at a room temperature that lies far below the desired value only slightly warmed supply air is blown into the rooms at a high channel pressure. This was hitherto felt to be disagreeable by the persons concerned, but it was regarded as unavoidable.

According to the present embodiment of the invention, heated air with the higher channel pressure is blown into the room only if the temperature of the supply air lies clearly above the predetermined desired temperature of the room and therewith, in the warming-up phase lies far above the actual value of the room. By a relation regulation in which the channel pressure of the supply air is set in a fixed relation to the supply air temperature, a corresponding coupling of channel pressure of the supply air pressure to the supply air temperature can be realized especially advantageously.

Preferably the channel pressure of the supply air into the room, the rooms, or the room zones is adjusted over the line of the supply air motor.

For a selecting arrangement a choice can be made between two delivery volume relations.

In the first place, for the heating case in which the desired value of the room temperature is less than the actual value of the room temperature, the channel pressure of the supply air is lowered with rising room temperature. Correspondingly, for the cooling case in which the desired value of the room temperature is greater than the actual value of the room temperature, the channel pressure of the supply air is lowered with falling room temperature. In the second place, for the heating case in which the desired value or the actual value of the room temperature is less than the supply air temperature and the actual value of the room temperature is less than the desired value of the room temperature, the channel pressure of the supply air is raised with rising supply air temperature. Correspondingly, for the cooling case in which the desired value or actual value of the room temperature is greater than the supply air temperature and the actual value of the room temperature is greater than the desired value of the room temperature, the channel pressure is raised with falling supply air temperature. The increase of the channel pressure of the supply air is found to be pleasant. Moreover, the efficiency of the heating and cooling apparatus is improved, as will be stated again further below.

According to a further embodiment of the invention the channel pressure of the supply air varies exclusively over a predetermined temperature range of the supply air temperature. If the supply air temperature presents a height before this temperature range, then the channel pressure of the supply air is allocated in each case to a certain constant magnitude. If the supply air temperature presents a height after the temperature range, then the channel pressure of the supply air is allocated in each case to a further determined constant magnitude.

In particular, with a supply air temperature higher with respect to the room temperature, the channel pressure rises over the predetermined temperature range of the channel pressure from its minimum performance up to its maximum performance with rising supply air temperature, and it correspondingly falls with falling supply air temperature.

Through the two regulating systems of the supply air channel pressure behavior, on the one hand it is made possible for the efficiency of the air-conditioning apparatus to be improved. With higher channel pressure of the supply air there is achieved also a more rapid and better flow through the room, and therewith a faster heating up of the rooms. On the other hand, for reasons of comfort, too great an air flow should be avoided, since this is felt to be disagreeable. The opposite demands are now optimally satisfied.

Here the regulating circuit which regulates the channel pressure of the supply air is subordinated to the temperature regulating circuit; the desired supply channel pressure value being set in a fixed relation to the actual value of the supply air temperature. Herewith there

is avoided any excessive increasing or decreasing in the temperature regulation. The room temperature swings back faster to the desired value temperature.

With air-conditioning for several rooms, the heated supply air is made available over a common supply air channel. In the case of different desired and actual temperatures of all the rooms, however, each room has a different heating requirement. In order to take this circumstance into account, according to a further form of execution of the invention, in the simultaneous air-conditioning of several rooms or room zones, the individual rooms or room zones are connected in each case over a supply air, and an exhaust air line allocated to them to the central supply air and exhaust air channel, and in the individual supply air and/or exhaust air lines throttle clack valves are arranged over which the channel pressure of the supply air is adjusted in the room, the rooms or room zones.

Thereby undesired air movements are avoided in rooms, the actual and desired values of which are alike or approximately alike. Moreover it is achieved that, for example, in the case of a fully open fresh air clack valve, an excessive amount of fresh air is not worked up.

The regulation of the clack valves can occur additionally in dependence on supply air pressure or on the turning rate of the supply air motor.

In such an independent regulation of supply air temperature and individual room temperature, a situation can arise in which a single room has to be heated as rapidly as possible, but other rooms that already lie at their desired temperature are to be heated up as little as possible. When the supply air temperature rises, the individual regulation of these warm rooms will tend to close the clack valves. Therewith, however, these rooms and the persons present in them are cut off from the fresh air supply.

This problem is advantageously solved according to a further embodiment, in which at a supply air temperature that lies above the desired temperature, in rooms the actual temperature of which corresponds to the desired temperature, the requisite minimum volume of fresh air also is blown. In this manner it is achieved that these rooms are supplied with sufficient fresh air; nevertheless, a possible warming of the rooms by reason of a supply air temperature that lies above the desired temperature is avoided insofar as possible. The minimal opening required for the prescribed minimum fresh air volume depends on the supply air temperature and on the fresh air component of the supply air, for the fresh air component of the supply air is reduced if possible warming-up phase in the morning for a maximally rapid heating up and replaced by return air.

According to one embodiment, the exhaust air channel and the supply air channel are connected with one another over a return air channel, in which case at least one air exhaust throttle clack valve is provided in the return air channel, and at least one fresh air throttle clack valve is provided in the fresh air channel engaged ahead of the supply air channel.

According to a further embodiment the minimum cross section of the throttle clack valves is adjusted in dependence on the opening of the fresh air throttle clack valve, of the

exhaust air throttle clack valve and of the mixing air throttle clack valve, so that in each regulation situation there is ensured the minimum amount of fresh air.

With regulated channel pressure for the supply air and for the exhaust air, the opening positions of the throttle clack valves allocated relative to one another in a room or in a room zone are equal.

Analogously to the heating regulation, there can also take place a cooling regulation.

For the temperature regulation, regulators are used. In practice, these regulators tend to an overswinging and underswinging of the regulating magnitude.

According to a further embodiment of the invention, in each case the setting value of at least one regulator, especially of the temperature regulator, is connected to a subordinated switching arrangement, and the switching arrangement, in the case of an overswinging (exceeding) of the regulating magnitude, selects a value predetermined for it, as the setting magnitude, which clearly lies under the value chosen simultaneously by the regulator.

Such a behavior can advantageously be obtained by an additional control arrangement and a minimum-selection arrangement. This additional control arrangement delivers, in dependence on the regulating difference, a predetermined minimal value for the setting magnitude when an overswinging of the regulating magnitude occurs, and a predetermined maximal value for the setting magnitude when the actual value of the temperature (the regulating magnitude) lies below the desired value. The minimum selection arrangement then in each case selects the minimum, from the values made available by the regulator and the additional control arrangement, and forwards the selected value as setting magnitude. In this manner the additional control arrangements always takes over the control of the setting magnitude when by reason of the setting magnitude of the regulator an overswinging (exceeding) occurs in the regulating magnitude.

According to a further embodiment of the invention there are provided a fresh air clack valve in a fresh air channel engaged on inlet side of the supply air channel, a mixed air clack valve in a return air channel connecting the supply air channel with the exhaust air channel, and a discharge air clack valve in a discharge air channel connecting to the exhaust air channel, in which situation the settings of the fresh air clack valve, of the discharge air clack valve and of the mixed air clack valve are regulated in common dependence on the turning rate of the supply air motor or on the channel pressure of the supply air, and in which up to a certain minimal opening for the ensuring of a fresh air minimum, with increasing turning rate of the supply air motor and/or with rising channel pressure of the supply air, the opening cross sections of the fresh air clack valve and of the discharge air clack valve can be reduced and the opening cross section of the mixed air clack valve can be increased.

The opening position of the fresh air clack valve and the opening position of the exhaust air clack valve are always of equal size. The opening position of the mixed air clack valve is always the difference of the opening position or the fresh air or exhaust air clack

valve to 100%, for example, if the opening positions of the fresh air clack valve and exhaust air throttle clack valve are each case 70%, then the opening position of the mixed air clack valve is 30%. If the mixed air clack valve has an opening position of 70%, then the opening positions of the fresh air and exhaust air clack valves are in each case 30%.

In a further preferred embodiment of the invention, more than one room is air-conditioned from a central installation. In the case of different heating requirements for the individual rooms, it is also necessary to make available over the supply air a sufficient heating capacity for all the rooms. This can be achieved inter alia by the means that the heating required is measured in accordance to the actual temperature of the coldest room, in order to bring also this room to the desired temperature in a short time. Accordingly, in one form of execution of the invention, in the simultaneous air-conditioning of several rooms the actual temperature of each room is fed to a central regulating arrangement, and a temperature value to be determined individually from these individual actual values is supplied as actual value for the heating regulator.

According to a further embodiment of the invention, a moistening arrangement is provided which humidifies the supply air in the supply air channel, in which process the humidifying arrangement is regulated both in dependence on the room moisture or the exhaust air moisture as well in dependence on the supply air temperature.

According to a further embodiment of the invention, there are provided a first heating device installed in the supply air channel, a cooling device engaged after the first heating device in the supply air channel, and a second heating device installed after the cooling device in the supply air channel for the heating, cooling and dehumidifying of the supply air, the second heating device being regulated for the desired value moisture in dependence on the actual value moisture.

In particular with a rising actual value humidity which already lies above the desired value humidity, the heating performance of the second heating device rises.

The heating performance of the second heating device is regulated either with a regulator or it climbs with rising actual value moisture over a predetermined moisture range of the room moisture; at a room moisture content before this moisture range the heating performance has in each case a certain constant magnitude and at a room moisture after the moisture range the heating performance has in each case a further determined constant magnitude.

It is hereby achieved that a dehumidifying is brought about over raising of the room temperatures insofar as the actual value of the room temperature remains under the limit value from which the cooling process is initiated. Cooling starts only when the actual value of the room temperature is greater than the desired value of the room temperature plus the temperature displacement dependent on the outside temperature. By the heating-up, and therewith the dehumidifying of the room over the rising temperature, the room is dehumidified rapidly and with a relatively low expenditure of energy.

The channel pressure of the supply air is not raised during the dehumidifying process.

In order to guarantee a minimum amount of fresh air in the room or the rooms, the regulation of the fresh air clack valve and of the discharge air clack valve occurs in dependence on the opening position of the mixed air clack valve.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings, which are included to provide further understanding of the present invention and are incorporated in and constitute a part of this specification, illustrate the preferred embodiments of the invention and together with the description serve to explain the principles of the invention.

In the simplest case, a single room is tempered and ventilated with the air-conditioning apparatus. The regulation of a multi-room air-conditioning is described in the example of execution with the aid of the drawing, in which:

- Fig. 1 shows a schematic representation of the air circulation in an air-conditioning apparatus according to the invention.
- Fig. 2 is a block circuit diagram with the most important elements of the regulating and control arrangements of the example of execution.
- Fig. 3 is a block circuit diagram with important elements of the temperature regulating circuit from Fig. 2.
- Fig. 4 is a block circuit diagram of the conveyance volume regulating circuit of the supply air from Fig. 2.
- Fig. 5 is a block circuit diagram of the individual temperature regulating circuit for each room from Fig. 2.
- Fig. 6a shows the relation between the supply air temperature and the supply air pressure for the example of execution when the room actual temperature is less than the desired value-room temperature.
- Fig. 6b shows the relation between the room temperature and the supply air pressure for the example of execution when the actual vacuum room temperature is greater than or equal to the desired value room temperature.
- Fig. 7 is a block circuit diagram of the temperature regulator of the example of execution.
- Fig. 8a is a block circuit diagram of the regulator of the exhaust air motor of the example of execution.

- Fig. 8b is the block circuit diagram with the most important elements from Fig. 8a.
- Fig. 8c shows the relation between the desired value of the room difference pressure for the regulator of the exhaust air motor.
- Fig. 9 shows the relation between the room exhaust air moisture and the setting magnitude for the after-heater.
- Fig. 10 is a run-off diagram with the most important block circuit diagram elements participating in the heating-up process.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In Fig. 1 there is schematically represented the air circulation of a multi-room air-conditioning system. From the rooms 1 to be air-conditioned there lead, on the one hand, supply air lines 5 to a supply air channel 10 and, on the other hand, exhaust air lines 6 to an exhaust air channel 11.

In the supply air line 5 there is arranged in each case a throttle clack valve 60 and in the exhaust air line 6 in each case a throttle clack valve 61.

The supply air channel 10 and the exhaust air channel 11 are connected with one another over a return air channel 12.

On inlet side of the supply air channel 10 there is engaged a fresh air channel 20 and on the outlet side of the exhaust air channel 11 there is engaged an exhaust air channel 21.

In the fresh air channel 20 there is provided a fresh air throttle clack valve 70, in the return air channel 12 a mixed air throttle clack valve 72 and in the exhaust air channel 21 an exhaust air throttle clack valve 71.

In the supply air channel 10 there are arranged successively in flow direction of the air a first heating device 30, a cooling device 40, a second heating device 33, a supply air motor 15 and humidifying device 50.

In the supply air channel there is generated by the supply air motor 15 an air pressure P_{ZU} which provides that the supply air is blown with sufficient conveyance volume into the rooms 1 to be air-conditioned.

Correspondingly in the exhaust air channel 11 there is generated by the exhaust air motor 16 a subpressure P_{AB} , which draws off the room air.

In the simplest case, the pure airing case (office operation) the drawn off room air (= the exhaust air) is given off over the exhaust air channel 11 and the exhaust air channel 21 to the outer atmosphere, and over the fresh air channel 20 the required supply air is drawn as fresh air into the supply air channel 10. For this the fresh air throttle clack valve

70 and the exhaust throttle air clack valve 71 are opened and the mixed air throttle air clack valve 72 is closed. The fresh air throttle clack valve 70 and the exhaust air throttle clack valve 71, there, always have equal opening settings.

In order to make possible a warming-up of the air-conditioned rooms 1, the drawn-in fresh air flows through the first heating device 30 (preheater) over which drawn-in air is brought according to heating requirement to the requisite supply air temperature T_{ZU} . After passing the disengaged cooling device 40 and the second heating device 33 (afterheater) it is fed to the humidifying arrangement 50, which supplies the necessary moisture to the air.

Instead of the first heating device 30, in a required cooling of the rooms to be air-conditioned the cooling device 40 is in operation. In the case of excessive humidity, instead of the moistening device 50 the afterheater 33 is in operation for the dehumidifying. In order to ensure a more rapid heating-up, both the first heating device 30 and also the second heating device 33 can be in operation. This, however is possible for the heating case, not for the dehumidifying case.

The air worked-up in this way is fed to the individual rooms to be air-conditioned, over the supply air motor 15, the supply air channel 10 and the supply air lines 5 with the throttle clack valves 60. The volume of the air blown-in and drawn off from each individual room can be regulated by the throttle clack valves 60, 61 arranged in the supply air lines 5 and in the exhaust air lines 6 individually.

In the case of increased heat requirement, for example in the morning warm-up phase, it is advantageous to supply the rooms not only with drawn-in fresh air, but to use a part of the drawn-off room air repeatedly, for in the simultaneous warming-up and ventilation the required supply air volume lies far over the fresh air minimum volume. For this reason, in dependence on the supply air temperature T_{ZU} over a control arrangement 500 in Fig. 2 a setting value Y_v is calculated and supplied to the air throttle clack valves 550 in Fig. 2, or 70, 71, 72 in Fig. 1.

While the fresh air throttle clack valve 70 and the exhaust air throttle clack valve 71 receive the same control signal, the mixed air throttle clack valve 72 in the return air channel 12, there, is supplied the exactly opposite control signal. The open position of the mixed air throttle clack valve 72 is always the difference between the open position of the fresh air clack valve 70 or of the exhaust air clack valve 71 and 100%. For example the open position of the fresh air clack valve 70 and of the exhaust air clack valve 71 amounts in each case to 70%, then the open position of the mixed air clack valve 30 amounts to 30%. If the mixed air clack valve has an open position of 70%, then the open position of the fresh air clack valve 70 and of the exhaust air clack valve 71 is in each case 30%.

In this manner it is possible again to feed a certain proportion of the drawn-off room air over the return air channel 12 to the supply air. Simultaneously over the fresh air channel 20 and the fresh air clack valve 70 a corresponding fresh air component is supplied to the supply air. This fresh air component amounts in the example of execution in the

airing case (during the office hours) to up to 100%. During office hours, therefore, the mixed air clack valve 72 as a rule is not opened, (and) the fresh air clack valve 70 and the exhaust air clack valve 71 are normally opened to 100% each. With increased heating requirement and a maximal supply air pressure $P_{ZU\ MAX}$ the fresh air component falls to approximately 10%—warming-up phase in the morning.

In the air-conditioning, from the measured room temperatures $T_{RAUM\ IST1}$, $T_{RAUM\ IST2}$ or $T_{RAUM\ IST\ N}$ in the minimal selection arrangement 400 in Fig. 2, the lowest value $T_{RAUM\ IST\ MIN}$ is determined and used for the calculation of the heating requirement. For this the actual temperature $T_{RAUM\ IST\ MIN}$ in the block circuit diagram element 100 is subtracted from the predetermined (maximal) desired temperature $T_{RAUM\ SOLL}$ (of all the rooms). On the basis of the temperature difference T (regulating difference), by the temperature regulation 130 there is determined a suitable desired value y' for the heating valve 170 of the heating device 30 in Fig. 1.

The setting value Y_R calculated in Fig. 3 for the temperature regulation is monitored by the circuited arrangement 125 arranged on outlet side in order largely to prevent an overswinging of the temperature usual with conventional regulators. In the normal case, as long as $T_{RAUM\ IST\ MIN}$ lies below $T_{RAUM\ SOLL}$, the arrangement 125 forwards the setting value Y_R unaltered as y' onward to the heating valve 170. If, however, $T_{RAUM\ IST\ MIN}$ exceeds the desired temperature $T_{RAUM\ SOLL}$ then, instead of Y_R a much smaller setting value y' will be forwarded on to the heating valve 170. The value of the setting magnitude y' assures in this case the minimally required supply air temperature $T_{ZU\ MIN}$, which is dependent on the outside temperature T_A . In this manner with the example of execution there is achieved a maximal overswinging of the desired temperature by only 0.3 °C; a falling below this virtually does not take place.

The monitoring of the setting signal Y_R of the regulator 120 is executed in the example of execution by a switching arrangement 127 in Fig. 7 and a minimum selection arrangement 128. The control arrangement simultaneously generates for the regulator 120 a setting signal Y_S which takes on a maximally great value as long as the desired temperature $T_{RAUM\ SOLL}$ lies above the actual temperature $T_{RAUM\ IST}$ and down to the very low setting $Y_S\ MIN$ as soon as the actual temperature exceeds the desired value.

The setting value $Y_S\ MIN$ of the control arrangement 128 is adjusted by the computing arrangement 129 for the cutting-off of the otherwise occurring underswinging of the temperature regulation in dependence on the outside temperature T_A with which the fresh air is drawn in.

The minimum selection arrangement 128 in each case selects, from the two setting value signals Y_R and Y_S at its disposal, the smaller one and forwards this onward as y' to the heating valve 170. In this manner there is prevented insofar as possible an overswinging of the temperature to be regulated.

In dependence on the temperature of the supply air the conveyance of the supply air motor 15 is adjusted over the generated supply air pressure P_{ZU} . For this first of all, in a

$P_{ZU\ SOLL}$ value calculating arrangement 200 shown in Fig. 2, there is determined a desired value $P_{ZU\ SOLL}$ for the supply air pressure. The relation between the supply air temperature T_{ZU} and the supply air pressure $P_{ZU\ SOLL}$ is given in Fig. 6a, and, namely, for the case in which the room temperature $T_{RAUM\ IST}$ is less than the desired value of the room temperature $T_{RAUM\ SOLL}$.

Only when the supply air temperature lies clearly above the desired value temperature, in the example of execution by 5 °C, is the desired pressure of the supply air increased. When this supply air temperature is below this threshold only the volume of air necessary for the ventilation of the rooms is blown into the air-conditioned rooms.

The relation between the room temperature $T_{RAUM\ IST}$ and the desired value of the supply air pressure $P_{ZU\ SOLL}$ is represented in Fig. 6b and, namely, for the case in which the room temperature $T_{RAUM\ IST}$ is greater than the desired value of the room temperature $T_{RAUM\ SOLL}$, or is equal to the desired value for the supply air temperature $T_{RAUM\ SOLL}$.

With increasing actual room temperature $T_{RAUM\ IST}$, when the room temperature is higher than the desired room temperature value $T_{RAUM\ SOLL}$, the air supply temperature T_{ZU} falls and the supply air pressure P_{ZU} falls from its maximal pressure $P_{ZU\ SOLL\ MAX}$ to its minimal pressure $P_{ZU\ SOLL\ MIN}$.

The desired supply air pressure $P_{ZU\ SOLL}$ determined by the $P_{ZU\ SOLL}$ value calculating arrangement 200 in Fig. 2 is compared in the block circuit diagram element 230 with supply air actual pressure

$P_{ZU\ IST}$. The pressure difference P is supplied to the pressure regulation 250.

The complete pressure regulating circuit is represented in Fig. 4. The regulating difference ΔP is fed to the regulator 240, which sets-in the setting magnitude Y_p . A limit value switch 245 monitors the setting value Y_p , so that a predetermined minimum pressure $P_{ZU\ MIN}$ which corresponds to a predetermined minimum ventilation volume is not gone below. The setting value Y_p of the limit value switch 245 controls the ventilator 285 in Fig. 4 or 15 in Fig. 1, which generates the pressure of the regulating stretch 286.

With the corresponding regulating circuit by an exhaust air motor 16 in the exhaust air channel 11 a subpressure P_{AB} is generated which, for the maintaining of a predetermined excess pressure in the rooms, draws off a corresponding volume of air. The regulation of the exhaust air motor 16 will still be further described below.

The tempered supply air in the supply air channel 10 is available over the supply air lines 5 for the ventilating and heating-up of all the rooms 1. With the aid of the throttle clack valves 60, 61, the volume of the air blown in or drawn off in each room is adapted to the particular actual heating requirement. For this in each case there are used the desired temperature, the actual temperature, the supply air temperature and the minimum ventilation volume for the setting of the throttle valves. This regulating circuit, represented in Fig. 2 as a block circuit forming element 300, is reproduced in Fig. 5.

In the block circuit element 310 the individual desired temperature $T_{SOL\ N}$ is compared with the corresponding actual temperature $T_{IST\ N}$; the regulating difference T_N ascertained there is supplied to the regulator 320. On the basis of the temperature difference, ΔT_N , of the supply air temperature T_{ZU} and of the supply air pressure P_{ZU} , this generates a setting signal Y_T which must not fall below a minimal value which is yielded from the actual supply air pressure P_{ZU} and from the minimal pressure $P_{ZU\ MIN}$. The setting signal $Y_{T\ N}$ is fed to the throttle clack valves 330 in Fig. 5, and 60, 61 in Fig. 1. The regulating stretch of this individual temperature regulating circuit is represented by the block circuit element 340.

The throttle valves 60, 61 are regulated, therefore, in dependence on the temperature desired value $T_{RAUM\ SOLL}$ in each room individually, on the temperature actual value $T_{RAUM\ IST}$ measured in each individual room, of the temperature value of the supply air temperature T_{ZU} , as well as in dependence on the supply air pressure P_{ZU} and/or the turning rate of the supply air motor.

As stated above, the regulating circuit ensures, for the adjustment of the opening cross section of the throttle valves 60, 61, a certain minimum opening cross section yielded in dependence on the supply air pressure, which cross section is not gone below in the adjustment of the throttle valves 60, 61. This minimum opening cross section is adjusted there in such manner that each room receives a predetermined absolute minimum fresh air volume.

The minimum opening cross section of the throttle valves 60, 61 is likewise adjusted in dependence on the opening of the fresh air clack valve 70 of the exhaust air clack valve 71 and of the mixed air clack valve 72.

With regulated conveyance volume of the supply air and of the exhaust air the opening settings of the throttle clack valves 60, 61 allocated to one another in a room 1 are equal.

In the regulating of the exhaust air motor 785 according to Fig. 8b, or 16 according to Fig. 1, the desired value for the exhaust air motor is calculated on dependence on the outside temperature in the $P_{DIFF\ SOLL}$ value calculating arrangement 710, in which operation this desired value forms a room excess pressure $P_{DIFF\ SOLL}$ established in respect to the outside pressure P_A in dependence on the outside temperature. The desired value $P_{AB\ SOLL}$ can also be determined in dependence on the supply air temperature and/or on the supply air pressure.

The relation between the outside temperature T_A and the desired value for the exhaust air motor / = desired value for the room excess pressure $P_{DIFF\ SOLL}$, which is yielded from the difference between the desired value of the exhaust air pressure $P_{AB\ SOLL}$ and the outside pressure P_A is represented in Fig. 8c. If the outside temperature T_A exceeds a certain limit value, for example an outside temperature of $-10\ ^\circ\text{C}$, the desired value $P_{DIFF\ SOLL}$ of the exhaust air motor falls with rising outside temperature from its maximum $P_{DIFF\ SOLL\ MAX}$ to its minimum $P_{DIFF\ SOLL\ MIN}$ with a further limit value, for example with an outside temperature of $+15\ ^\circ\text{C}$. At an outside temperature before or after this temperature range

established by the two limit values, the desired value of the exhaust air motor $P_{\text{DIFF SOLL}}$ corresponds either to the maximal room difference pressure $D_{\text{DIFF SOLL MAX}}$ or to the minimal room difference pressure $P_{\text{DIFF SOLL MIN}}$.

The desired value of the exhaust air motor $P_{\text{DIFF SOLL}}$ determined by the value calculating arrangement 710 in Fig. 8a is compared in the block circuit diagram 700 with the room difference actual pressure value $P_{\text{DIFF IST}}$ in one room and in several rooms with the supply air and exhaust air channel pressure differential. The pressure difference ΔP is fed to the pressure regulation 730.

The complete pressure regulating circuit is presented in Fig. 8b. The regulating difference ΔP_{DIFF} is fed to the regulator 740, which adjusts the setting magnitude $Y_{\text{P DIFF}}$. If in a large room office several windows are open, the exhaust fan can be shut off entirely--only in this way is it possible to maintain a slight excess pressure. With the setting value $Y_{\text{P DIFF}}$ of the regulator 740 the exhaust air motor 785 in Fig. 8b, or 16 in Fig. 1 which generates the pressure of the regulating stretch 786 is controlled.

The actual value for the regulator 740 of the exhaust air motor 16 or 785 is formed by the actual room difference pressure $P_{\text{DIFF IST}}$, which is yielded from the difference between the outside pressure P_A and the room pressure $P_{\text{RAUM IST}} = P_{\text{AB IST}}$. The room difference pressure $P_{\text{DIFF IST}}$ is measured there at a level above 0 (sea level).

The form of execution described can be used analogously for the cooling.

In an additional regulating circuit, the air humidity in the air-conditioned rooms is regulated. It is measured preferably as relative air moisture (in percent of the vapor pressure at full saturation) and expressed by a simplified designation F in the following. It is entirely possible, however, to use instead of the relatively humidity the absolute humidity (g of water vapor per m³ of air), the vapor pressure, the specific moisture (in g H₂O per kg of moist air) or as mixture ratio (in g H₂O per kg of dry air). With use of the relative humidity, the dependence on the saturation limit is advantageously integrated into the value. According to the VDI ventilation rules, air humidity should amount in winter, at 20 °C room temperature, to 35% to 70% relative air humidity, and, in summer, at 22 °C air temperature, to 70%, and at 25 °C, to 60%.

In the block circuit element 600 in Fig. 1, there is determined the difference between the desired air moisture $F_{\text{AB SOLL}}$ and actual air moisture $F_{\text{AB IST}}$, in which representationally for the air moisture in the individual rooms in the example of execution, the moisture of the exhaust air F_{AB} is measured and adjusted. The determined moisture difference ΔF_{AB} is first introduced into a limit value circuit device 610, which on the basis of predetermined minimal and maximal moisture $F_{\text{AB MIN}}$ and $F_{\text{AB MAX}}$, in dependence on the supply and exhaust air temperature, prevents the saturation limit from being exceeded in any place in the air circulation. From this limit value switching device 610, a corrected regulating difference ΔF_{AB} is now led to the regulator 620, which controls the air moistener 630 over the control signal Y_L . Thereby, the moisture of the supply air F_{ZU} is adjusted. The regulating stretch is represented by the block circuit diagram element 640.

The second heating device 33, in the heating case, may also contain the signal Y' of the first heating device 30. The second heating device (33) serves, however, as an after-heater essentially for the dehumidifying. This second heating device (33) is regulated in dependence on the actual value moisture F_{IST} for the desired value moisture, in which with rising actual value moisture F_{IST} over the desired value moisture F_{SOLL} the heating performance of the second heating device (33) rises. The rise of the heating performance of the second heating device (33) moves over a predetermined moisture range of the room moisture F_{IST} . This relation is represented in Fig. 9. At a room moisture F_{IST} before this moisture range, the second heating device (33) is not in operation.

At a room moisture F_{IST} after this moisture range, the second heating device (33)—the after-heater—is in operation with its maximal performance.

By a control arrangement (not represented here) it is made certain that the conveyance volume of the supply air is not increased during the dehumidifying process and that only a minimum amount of fresh air is blown in.

For a better illustration of the regulating system, in the following there is described, by way of example, a warming-up process such as ordinarily takes place in the morning. The block circuit diagram elements participating in the run-off of the regulation are represented in Fig. 10. At the time point when the switching-on of the air-conditioning apparatus takes place, the actual temperatures of all the rooms 1 and the temperature of the drawn-in fresh air lie far above the desired temperature for the rooms 1. Since the temperature of the supply air is still very low, no more supply air is blown into the rooms. For this, a minimal air pressure $P_{ZU MIN}$, corresponding to the minimum of fresh air volume, is generated.

At a lower outside temperature below 16 C, the regulator is prior-occupied at the start with a value according to the outside temperature, so that the installation will show no frost disturbance in the starting.

From the actual temperatures of all the rooms 1 to be air-conditioned, the minimum-selection arrangement 400 selects the lowest value and conducts this to the block circuit diagram element 100. Here the regulating difference ΔT between the desired and actual value of the room air temperatures is formed and supplied to the regulator 120 and the control arrangement 127. On the basis of the regulating difference ΔT , the regulator 120 determines a setting value Y_R . Simultaneously with the control arrangement 127, a setting value Y_S is determined, which takes on a maximally great value as long as the desired temperature lies above the actual temperature. Of the two setting values Y_S and Y_R , the minimum selection arrangement 128 selects the smaller one, at this time point the setting value Y_R of the regulator 120, and conducts it onward to the heating device (30). This warms up the air flowing through the air supply channel (10). Therewith, the air supply temperature T_{ZU} rises continuously. From a predetermined temperature threshold value of the air supply, for example $T_{ZU SOLL} + 5^\circ \text{C}$, with further rising air supply temperature, the air supply pressure also is increased, since the regulation of the air supply pressure occurs in

dependence on the temperature of the air supply. The conveyance volume increases and there takes place a maximally rapid heating-up of all the rooms.

The increased air volume consists not only of fresh air, but a part of the exhaust air again is conducted to the supply air over the environmental air channel 12 in Fig. 1. In this manner, the rooms 1 are sufficiently ventilated and, simultaneously, it is not necessary to heat up much fresh air needlessly.

In the morning heating-up, the fresh air constituent is only—at least—such that the requisite excess pressure is achieved.

When the heating-up process is concluded, usual commercial regulators do not lower the setting value rapidly enough to prevent a rise of the actual temperatures of the rooms 1 over the desired temperature. For this reason the setting value Y_S of the control arrangement 127 on exceeding of the desired temperature falls to a predetermined minimal value $Y_{S \text{ MIN}}$. Now the minimum selection arrangement 128 selects the value Y_S of the control arrangement 127 and passes it onward as y' to the heating device 30. Thereupon the air supply temperature again falls, and after a short time the rooms again receive only the minimum fresh air volume that is sufficiently tempered to prevent a lowering of the actual temperature of the air supply below the desired temperature of the air supply. The regulator can therefore slowly reduce its output.

Now there is to be described in addition the case in which only one room has to be heated, while the other rooms have already reached the desired temperature. The selection arrangement 400 selects the lowest actual temperature of the unheated rooms and passes it on to the block circuit diagram element 100. On the basis of the regulating difference now a setting value y' is set in and the supply air pressure rises correspondingly. So that the rooms will not be supplied with very warm supply air which have already reached the desired temperature, however, the individual room temperature regulation 3000 regulates the blow-in air volume of the throttle clack valves 60, 61 for each room separately.. In this manner the throttle valves 60, 61 of the rooms in which the actual temperature are closed to the minimum opening, which ensures that the rooms are sufficiently ventilated. Simultaneously, the throttle valves 60, 61 of the room being heated rising T_{zu} is opened up by the P_{DIFF} , up to 100%, in order to make possible a rapid heating-up. Only when this room has reached its desired temperature does the air-conditioning regulation again set in the minimum ventilation and desired temperature holding state.

It will be apparent to those skilled in the art that various modifications and variations can be made in the air-conditioning apparatus of the present invention without deviating from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this inventions provided they come within the scope of the appended claims and their equivalents.

CLAIMS:

1. An air-conditioning apparatus for controlling condition, for example, temperature, in at least one room to a predetermined temperature desired value by ventilation with heated or cooled supply air, comprising:

a supply air motor which provides the supply air over a supply air channel to the room to be air-conditioned;

a cooling and/or heating device for cooling or warming of the supply air;

an exhaust air motor, which draws exhausted air over an exhaust air channel out of the room to be air-conditioned, and

a regulator of the exhaust air motor for forming a room excess pressure with respect to the outside pressure

2. The air-conditioning apparatus according to claim 1, wherein a desired value for the regulator of the exhaust air motor is determined by outside temperature and/or supply air temperature and/or supply air pressure.

3. The air-conditioning apparatus according to claim 2, wherein the actual value for the regulator of the exhaust air motor is formed by a channel pressure differential calculated from a difference between an absolute value of the pressure in the supply air channel and an absolute value of the pressure in the exhaust air channel.

4. The air-conditioning apparatus according to claim 2, wherein the actual value for the regulator of the exhaust air motor is formed by the room pressure differential which is yielded from the difference between the outside pressure and the room pressure

5. The air-conditioning apparatus according to claims 3, wherein the room excess pressure changes exclusively over a predetermined temperature range of the outside temperature and/or of the supply air temperature with change of the outside temperature or of the supply air temperature, in which with an outside temperature or supply air temperature before this temperature range the room excess pressure has in each case a certain constant magnitude and with an outside temperature after this temperature range the room excess pressure has in each case a further determined constant magnitude.

6. The air-conditioning apparatus according to claims 5, wherein within the temperature range the room pressure falls with rising outside temperature from a maximal excess pressure to a minimal excess pressure.

7. The air-conditioning apparatus according to claim 6, wherein the room pressure differential is measured at a level above 0, where room height corresponds to outside height in respect to sea level.

8. The air-conditioning apparatus according to claim 7, wherein the temperature of the supply air and the channel pressure of the supply air are coupled with one another in such manner that both in dependence on the level of the room temperature to the level of the room air supply temperature, and also in dependence on the level of the room temperature

to the level of the desired value of the room temperature the channel pressure of the supply air into the room, the rooms or room zones is raised or lowered.

9. The air-conditioning apparatus according to claim 8, wherein the channel pressure of the supply air into the room, the rooms or room zones is adjusted over the performance of the supply air motor.

10. The air-conditioning apparatus according to claim 9, wherein in case when the desired value of the room temperature is less than the actual value of the room temperature, the channel pressure of the supply air is lowered with rising room temperature.

11. The air-conditioning apparatus according to claim 10, wherein in case when the desired value of the room temperature is greater than the actual value of the room temperature the channel pressure of the supply air is reduced with falling room temperature.

12. The air-conditioning apparatus according to claim 11, wherein in case when the desired value or actual value of the temperature is less than the supply air temperature and the actual value of the room temperature is less than the desired value of the room temperature, the channel pressure is raised with rising supply air temperature.

13. The air-conditioning apparatus according to claim 12, wherein in case when the desired value or actual value of the room temperature is greater than the supply air temperature and the actual value of the room temperature is greater than the desired value of the room temperature, the channel pressure is increased with falling supply air temperature.

14. The air-conditioning apparatus according to claim 13, wherein the channel pressure of the supply air varies exclusively over a predetermined temperature range of the supply air temperature, with a supply air temperature before this temperature range the channel pressure of the supply air always has a certain constant magnitude and with a supply air temperature after the temperature range the channel pressure of the supply air always has a further determined constant magnitude.

15. The air-conditioning apparatus according to claim 11, wherein with a supply air temperature higher with respect to the room temperature, over a certain temperature range the channel pressure of the supply air increases from its minimum performance up to its maximum performance with rising supply air temperature and with decreasing supply air temperature it falls correspondingly.

16. The air-conditioning apparatus according to claim 9, including the regulating circuit which regulates the channel pressure of the supply air, said circuit is connected to the temperature regulating circuit, the channel pressure desired-value guide magnitude of the conveyance volume circuit being settable in a fixed relation to the supply air temperature actual value.

17. The air-conditioning apparatus according to claim 16, wherein in simultaneous air-conditioning of several rooms or room zones the individual rooms or room zones in each

case are connected, over a supply-air and exhaust-air lines to the central supply-air and exhaust-air channels and that in the individual supply-air and/or exhaust air lines there are arranged throttle clack valves over which the channel pressure of the supply air into the room, rooms or room zones is adjusted.

18. The air-conditioning apparatus according to claim 17, wherein the throttle clack valves are settable in dependence on the channel pressure of the supply air or the turning rate of the supply air motor.

19. The air-conditioning apparatus according to claim 18, wherein a regulating circuit for the setting-in of the opening cross section of the throttle clack valves does not go below a minimum opening cross section yielded in dependence on the channel pressure of the supply air in the adjustment of the throttle clack valves, and the regulating circuit sets in this minimal opening cross section in such manner that each room receives a predetermined absolute minimum fresh volume.

20. The air-conditioning apparatus according to claim 17, wherein the exhaust air channel and the supply air channel are connected with one another over a return air channel, there being provided at least one exhaust air clack valve in the exhaust air channel connecting to the exhaust air channel, at least one mixed air clack valve in the return air channel, and at least one fresh air clack valve in the fresh air channel engaged before the supply air channel.

21. The air-conditioning apparatus according to claim 20, wherein the minimum opening cross section of the throttle clack valves is adjusted in dependence on the opening of the fresh air clack valve, the exhaust air clack valve, and the mixed air clack valve.

22. The air-conditioning apparatus according to claim 21, wherein with regulated conveyance volume of the supply air and of the exhaust air the opening settings of the throttle clack valves in a room or a room zone are equal.

23. The air-conditioning apparatus according to claim 22, wherein the setting magnitude of at least one regulator, especially of the temperature regulator, is connected to a switching arrangement on outlet side, and the switching arrangement on an overswinging of the regulating magnitude selects a value predetermined for it for the setting magnitude which lies below the value simultaneously selected by the regulator.

24. The air-conditioning apparatus according to claim 23, including a fresh air clack valve in a fresh air channel engaged before the supply air channel, a mixed air clack valve in a return air channel connecting the supply air channel with the exhaust air channel, and a discharge air clack valve in a discharge air channel connected to the exhaust air channel, in which the settings of the fresh air clack valve, of the discharge air clack valve and of the mixed air clack valve are regulated in common in dependence on the turning rate of the supply air motor or on the channel pressure of the supply air, and in which up to a certain minimum opening for the ensuring of a fresh air minimum with increasing turning rate of the supply air motor and/or with increasing channel pressure of the supply air, the

opening cross sections of the fresh air clack valve and of the exhaust-air clack valve are reduced and the opening cross section of the mixed air clack valve is increased.

25. The air-conditioning apparatus according to claim 24, wherein for simultaneous air-conditioning of several rooms the actual temperature of each room is fed to a central regulating arrangement, and that a temperature value to be determined individually from these actual values is selected and supplied as actual value for the heating regulator.

26. The air-conditioning apparatus according to claims 25, including a moistening arrangement, which moistens the supply air in the supply air channel, in which the moistening arrangement is regulated both in dependence on the room moisture or on the humidity of the exhaust air and also on the supply air temperature.

27. The air-conditioning apparatus according to claim 26, including a first heating device installed in the supply air channel, a cooling device engaged on outlet side of the first heating arrangement in the supply air channel and a second heating device engaged on outlet side of the cooling device in the supply air channel, in which the second heating device is regulated in dependence on the actual value moisture for the desired value moisture.

28. The air-conditioning apparatus according to claim 27, wherein with rising of the actual value moisture over the desired value moisture, the heating performance of the second heating device rises.

29. The air-conditioning apparatus according to claim 28, wherein the heating performance of the second heating device is regulated with a regulator, or with the rising actual value moisture rises exclusively over a predetermined moisture range of the room moisture, with a room moisture before this moisture range, the heating performance has a certain constant magnitude and with a room moisture after the moisture range the heating performance always has a further determined constant magnitude.

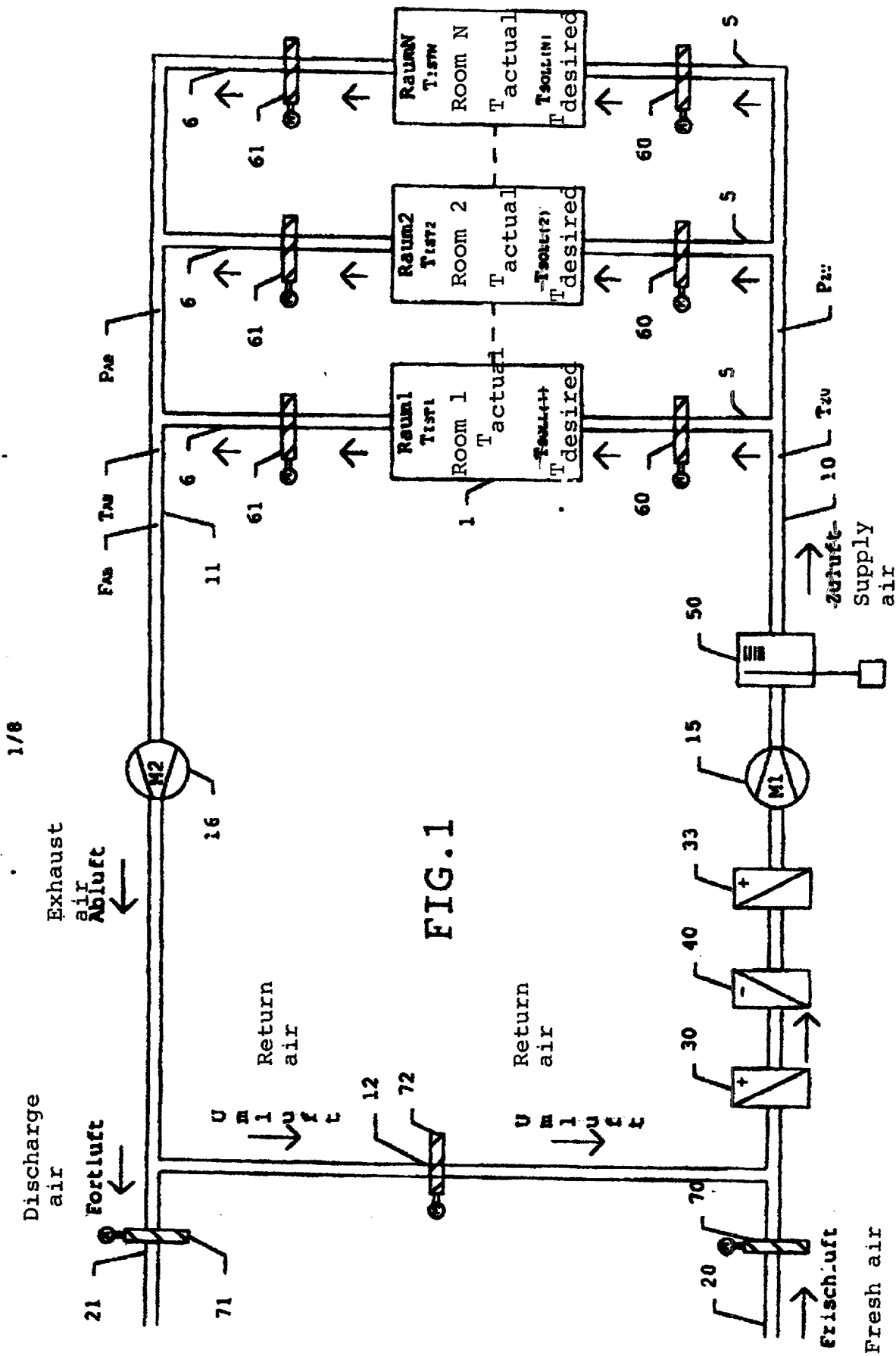
30. The air-conditioning apparatus according to claim 29, wherein the channel pressure of the supply air is not increased during the dehumidifying process.

31. The air-conditioning apparatus according to claim 23, wherein the fresh air clack valve and the exhaust air clack valve are settable in dependence on the opening setting of the mixed air clack valve.

ABSTRACT

The invention relates to an air-conditioning apparatus which regulates at least the temperature of at least one room to a predetermined temperature desired value ($T_{\text{RAUM SOLL}}$) by ventilation with heated or cooled supply air. The air-conditioning apparatus has a supply air motor (15) which feeds the supply air over a supply air channel (10) to the room (1) to be air-conditioned, a cooling and/or heating device (30, 40 33) for the cooling or warming of the supply air, and an exhaust air motor (16) which draws the exhaust air from the room (1) to be air-conditioned over an exhaust air channel (11). According to the invention, the desired value ($P_{\text{AB SOLL}}$) for the regulator of the exhaust air motor (16) forms a room excess pressure established with respect to the outside pressure (P_{A}).

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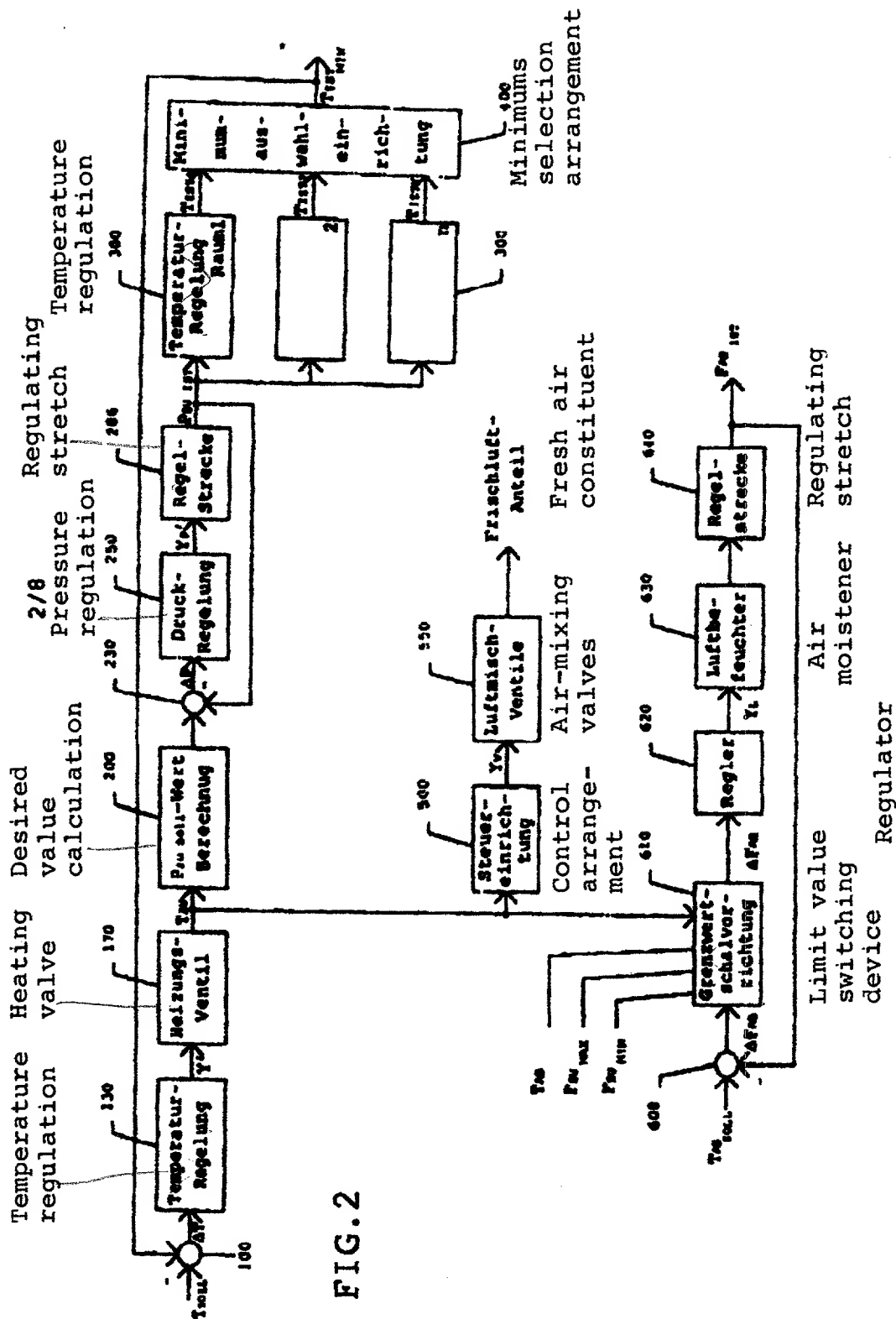


FIG. 2

FIG. 3

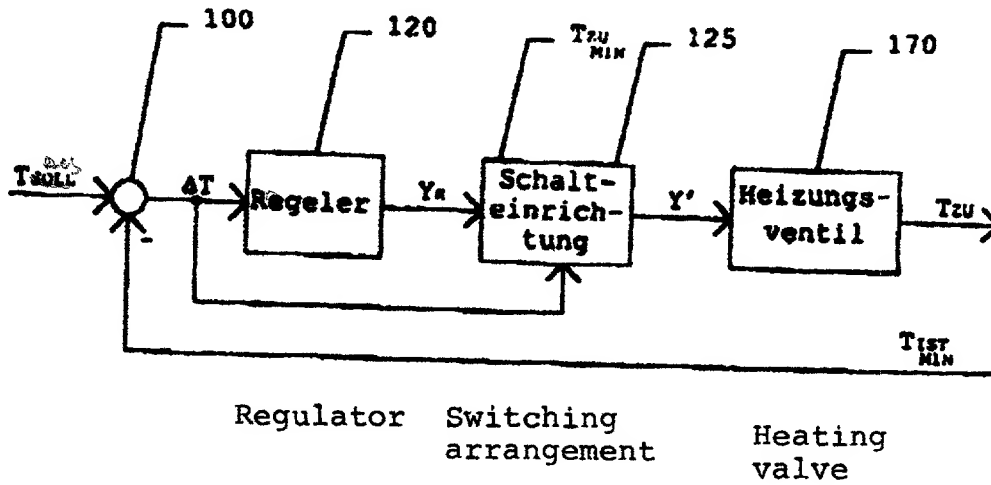


FIG. 4

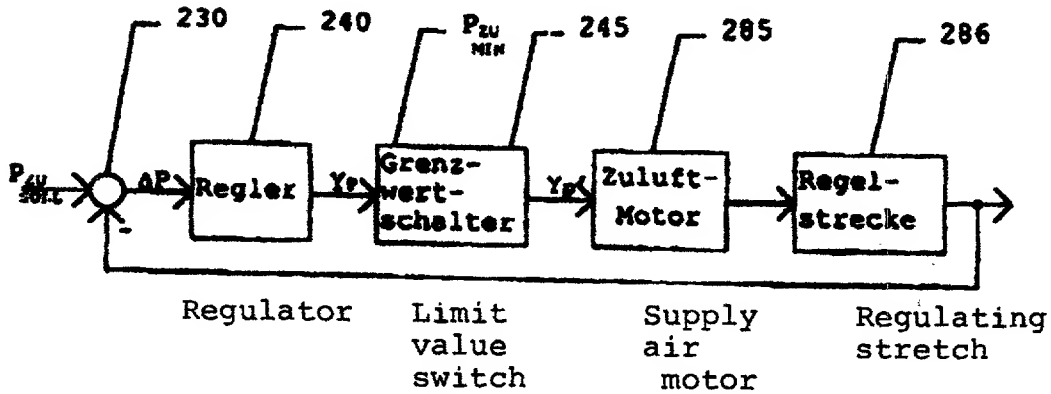


FIG. 5

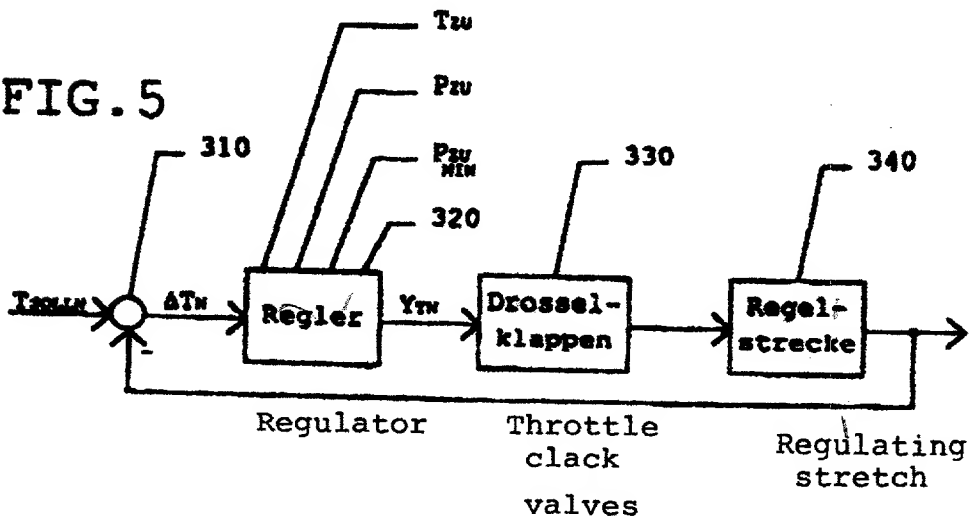


FIG. 6a

$T_{RAUM\ IST} < T_{RAUM\ SOLL}$

Actual temperature less than desired temperature

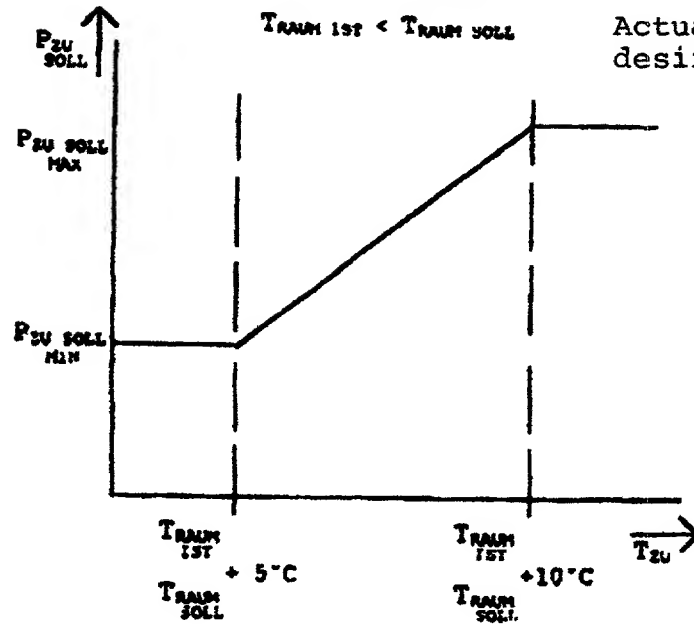


FIG. 6b

$T_{RAUM\ IST} \geq T_{RAUM\ SOLL}$

Actual temperature greater than or equal to desired temperature

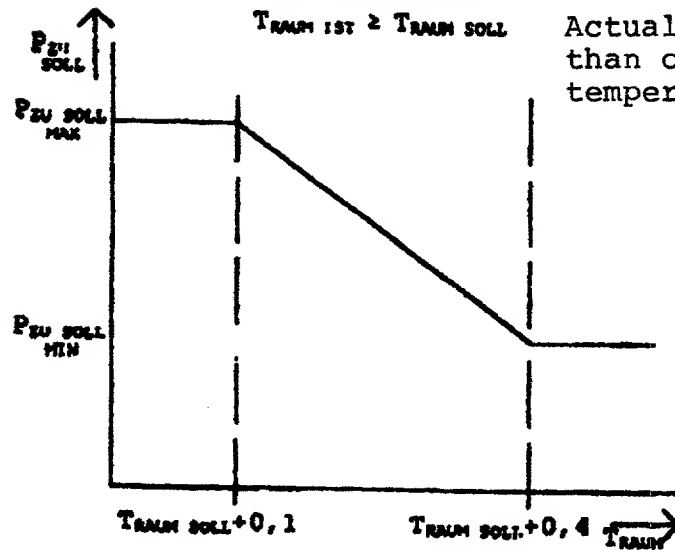
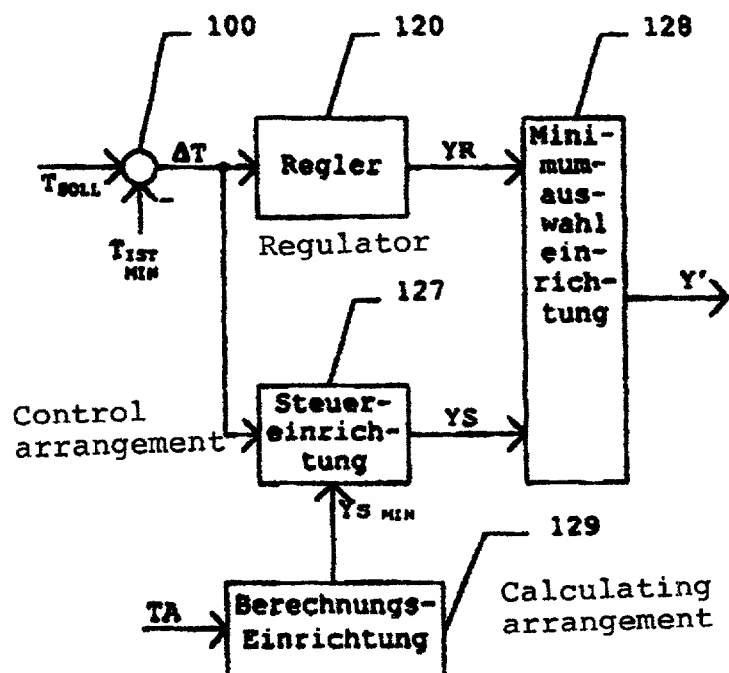


FIG. 7



Minimum
selection
arrangement

Calculating arrangement

[illegible]

FIG. 8a

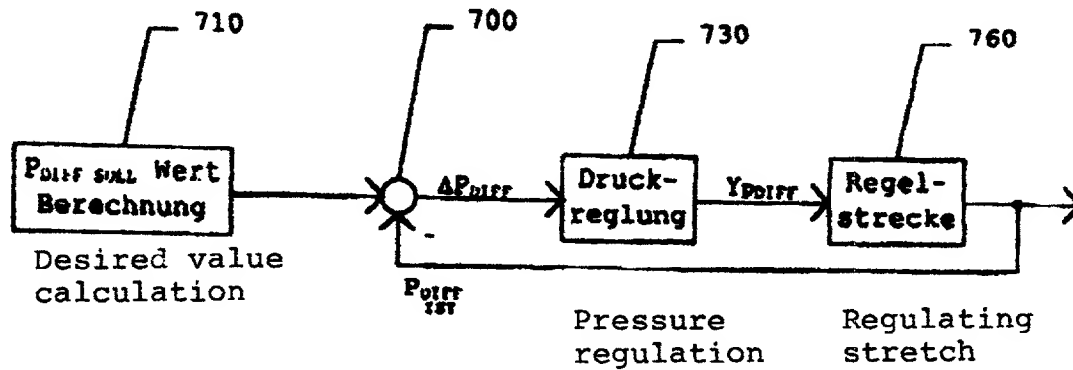


FIG. 8b

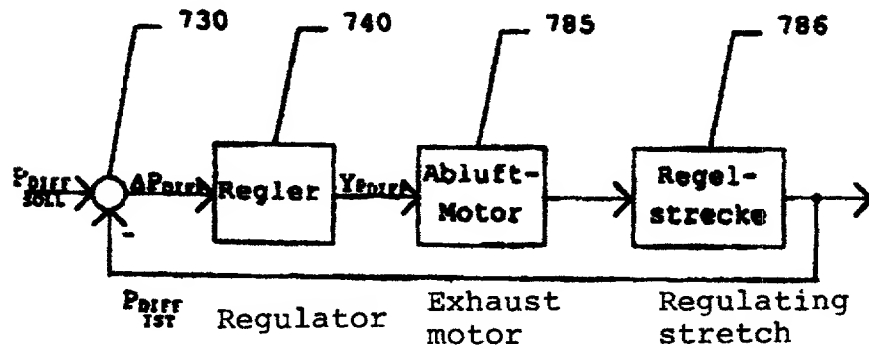


FIG. 8c

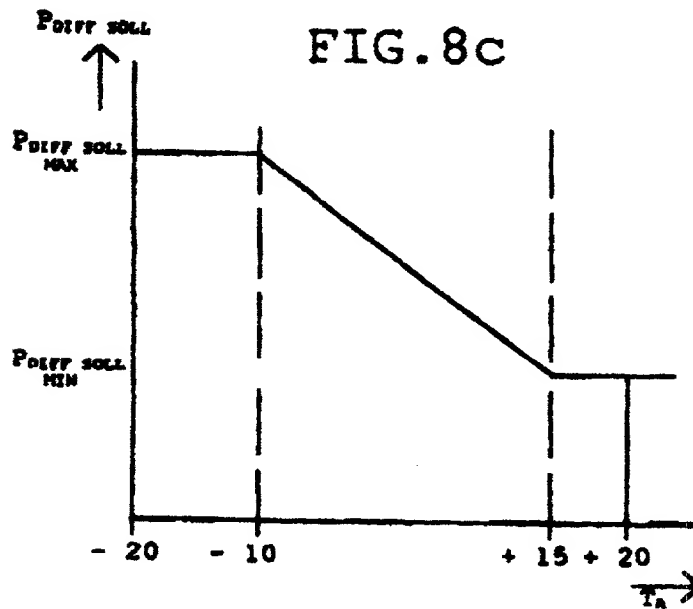


FIG.9

After-heater

Nacherhitzer

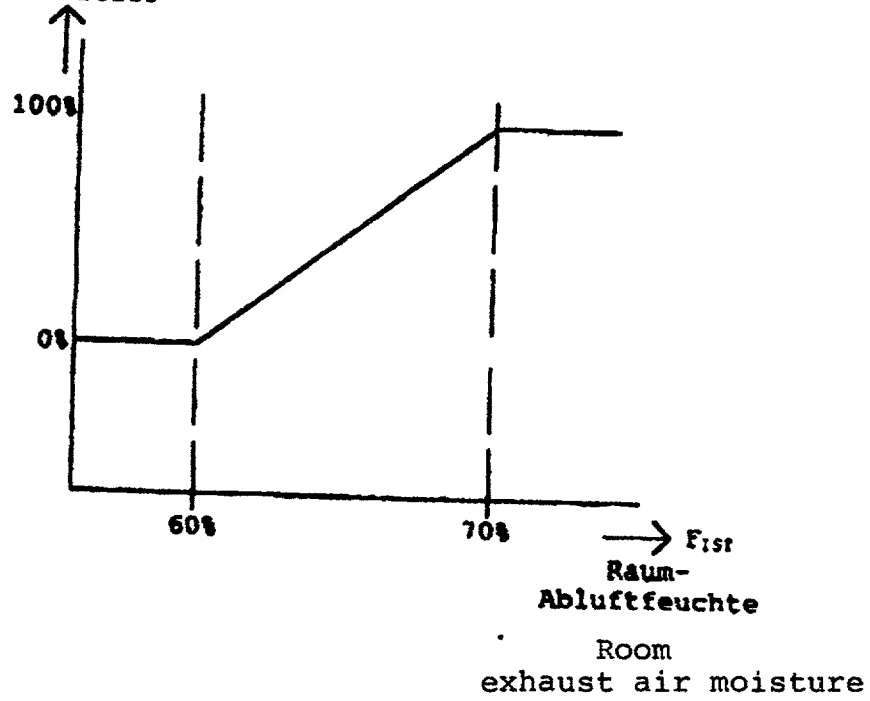
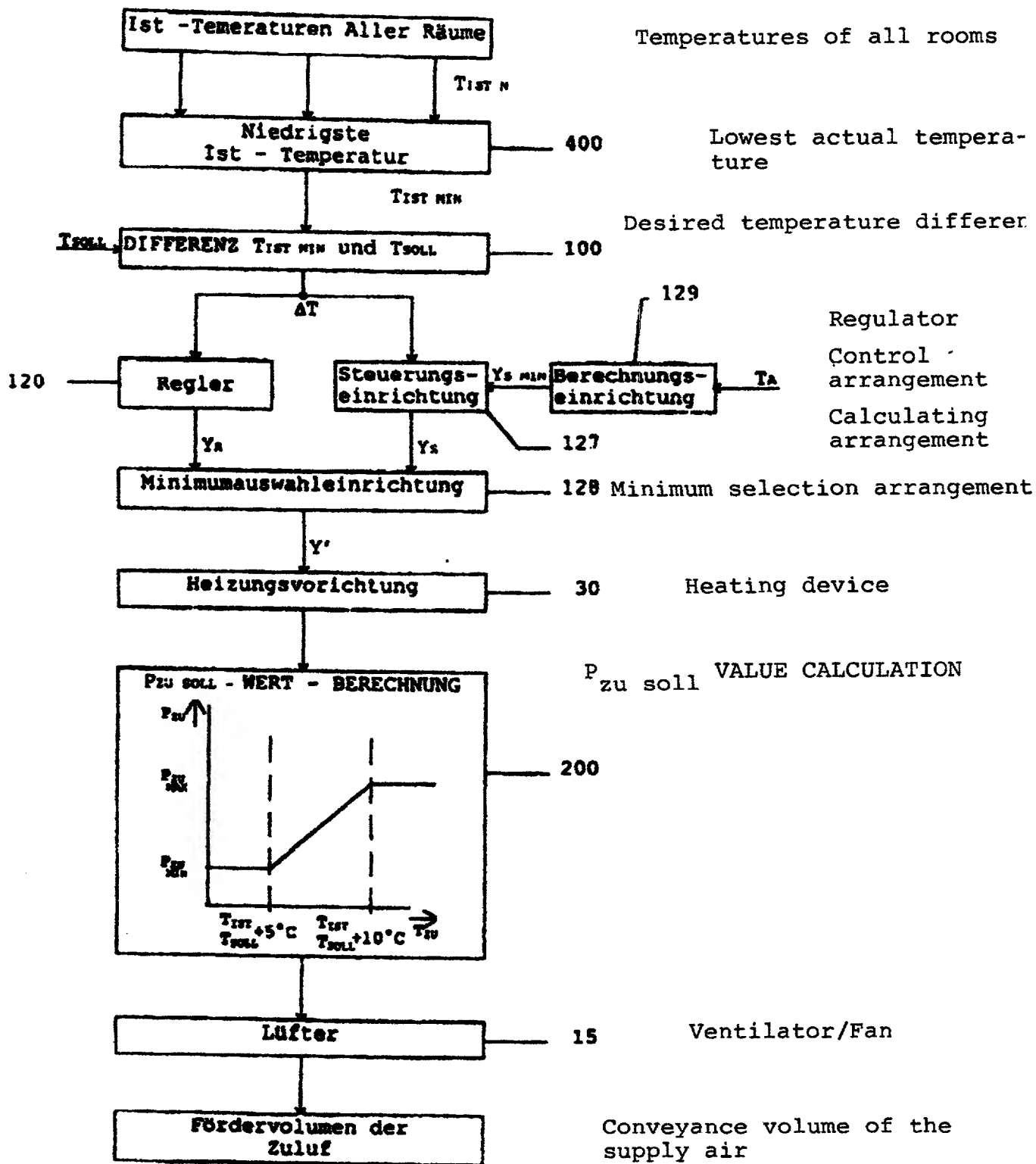
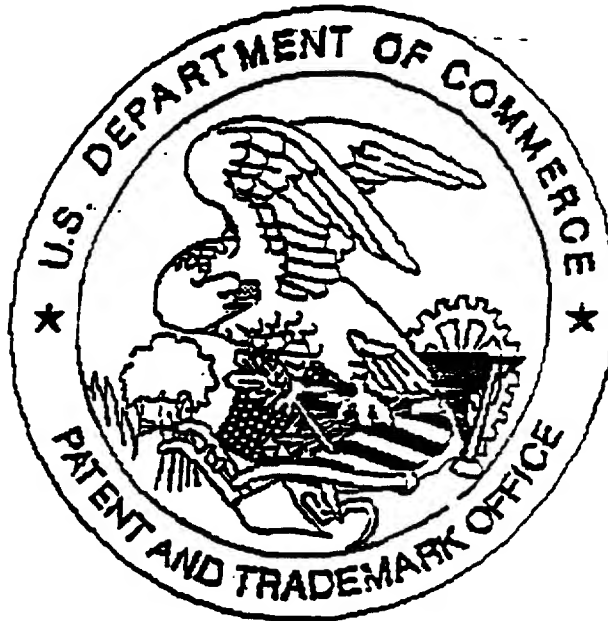


FIG. 10



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